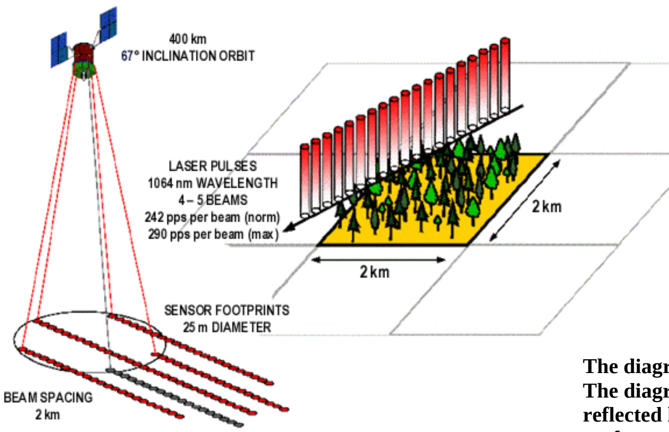
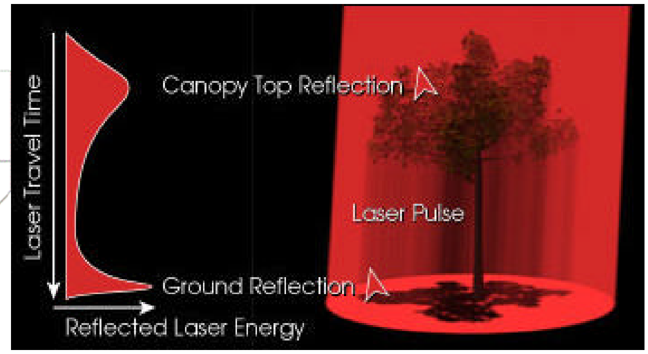
Introduction

What is lidar? Lidar is an acronym for ***L***ASER ***I***maging ***D***etection ***A***nd ***R***anging, and the word laser itself is the acronym for ***L***ight ***A***mplification by ***S***timulated ***E***mission of ***R***adiation. A laser is a device that controls the way that energized atoms release photons, and how it works is very succinctly described by the name itself – light amplification by stimulated emission of radiation! Lidar experiences large attenuations in clear air in the millimeter (60GHz) and sub-millimeter regions, but these are not present in the infrared and visible regions, though the attenuation is still large in the presence of rain. Lidar enjoys the advantages of high angular resolution, wide bandwidth, and Doppler frequency sensitivity. Lidar has a characteristic small physical aperture that is not suited for most surveillance applications but more for precision measurement and target imaging. The primary wavelengths of laser radiation include the ultraviolet, visible, and infrared regions of the electromagnetic spectrum. Ultraviolet radiation for lasers consists of wavelengths from 180nm to 400nm, 400nm to 700nm for the visible light region, and 700nm to 1mm for the infrared region. Being part of the EM spectrum, lidar operations follow the principles of other radars, but only for some exceptions.

System Description and Application

For this project, I have chosen the ***M***ulti-***B***eam ***L***aser ***A***ltimeter (MBLA) for its application in the ***V***egetation ***C***anopy ***L***idar (VCL) mission. The MBLA is a five-beam instrument used to measure vegetation canopy heights, vertical distributions of intercepted surfaces, and the topographic elevations to less than 1m. The five beams are in a circular configuration 8km across and each beam traces a separate ground track spaced 2km apart, with 25m contiguous along track resolution, eventually producing 2km coverage between 67° N and S, with orbit crossovers producing a denser grid away from the equator. Each laser beam operates at the 1064nm fundamental wavelength of the neodymium-doped yttrium aluminum garnet (Nd:YAG) solid-state laser and these are arranged in a pentagon inside a 20mrad telescope circular field-of-view. The 0.9m diameter optical telescope composed of beryllium. For the VCL mission, the MBLA instrument will be carried by a small satellite, operating in a 400km orbit of 67° inclination with a two-year nominal lifetime. VCL makes simultaneous measurements of range to the surface by synchronous triggering of the 5 laser pulse transmitters and detection with a single telescope that is staring at nadir and is equipped with multiple silicon avalanche photo diode detectors in its focal plane. Surface echoes from the 5 beams are digitized in the MBLA electronics at 250 Mega-samples per second to achieve the required sub-meter vertical resolution in the vegetation canopy and permit pulse centroid correction of the range measurement. The MBLA pulsed laser transmitter modules employ the Q-switching technique to concentrate laser energy in a short pulse. Each of these laser modules produces a laser pulse of 5 nano-second duration at the rate of 242pps. Laser pulse energy of 10mJ per pulse will be sufficient to establish a link performance for the MBLA instrument that results in 95% probability of detection of the Earth's surface under clear atmospheric conditions and permits surface lidar investigations. The VCL provides a direct measurement of the height of the forest's leaf-covered canopy, the topography of the forest floor and the height of all the vegetation in between.





The diagram on the left shows details of the Vegetation Canopy Lidar mission. The diagram on the right shows how the VCL measures forest height by detecting reflected laser light. Lidar sensors measure elevation by bouncing laser light off a surface and measuring the time the light pulse takes to return.

Summary of Instrument Description	
Lasers	3-5 Nd:YAG diode-pumped pulsed lasers, operating at 1064nm wavelength
Laser Pulses	242 pps (land), 10mJ per pulse
Telescope	0.9m f/1 parabolic mirror with 20 mrad total FOV and 0.3 mrad IFOV
Detectors	Si avalanche photodiodes
Waveform Digitization	250 Mega-samples/sec
Swath Width	8 km
Resolution	25m (60µrad) footprint diameter of 400km altitude
Tracking Spacing	2 km
Elevation Accuracy	<1m in low slope terrain
Vegetation Height Accuracy	< 1 m limited by 100:1 pulse detection dynamic range and cal/val
Communications	S-band command and telemetry, X-band 28 Mbps science downlink
Uplinks/Downlinks	2 to 3 command loads per week, 4 data downlinks per day
Data Volume	2.2 Gbyte/day compressed, 5.0 Gbyte/day de-packetized
Orbit	390 - 410 km, 67° inclination

Summary and Comments on Potential Utility for the Military

VCL not only allows mapping of the top of the forest canopy and the ground beneath, but also a vertical record of everything in between. This will enhance military mapping efforts, as it provides military mapping agencies the means to collect sub-canopy topographic data that is never available before. A comprehensive data-base can also be a useful reference to contrast the presence of any anomaly, like the presence of missile launchers, armor vehicles, tanks, and troops that may be operating under the cover of thick vegetation.

Bibliography

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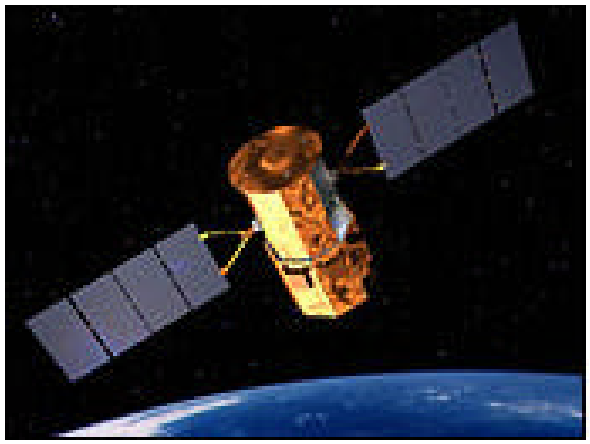
Picture of the Vegetation Canopy Lidar satellite



http://earthobservatory.nasa.gov/Library/VCL/

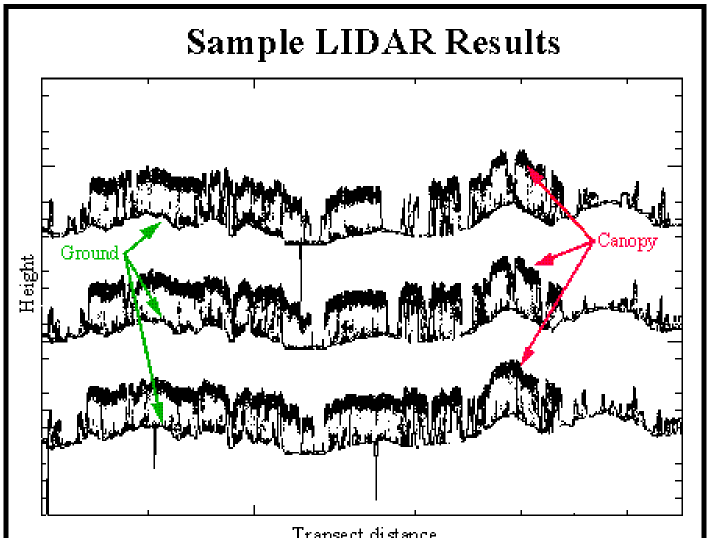


Figure 3. Sample results of a LIDAR pass over a forest stand. In each of the three laser-tracks it is possible to delineate the canopy and the ground. From this image, it is possible to locate gaps in the canopy, tree height, ground surface form, changes in canopy characteristics (e.g., density, closure). Image credit http://ltpwww.gsfc.nasa.gov/eib/slicer.html.